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ABSTRACT

This study, which indicates that both age and variation in training affect children's concept formation, provides a basis for explaining the effect of age. Sixty-four 4- and 5-year-olds learned three novel concepts (animal-like, plant-like, and machine-like). Subjects were presented with either four different examples of each concept (multiple item training condition) or with one example of the concept which was repeated four times (single item training condition). Following acquisition, children identified a set of recognition, generalization, and discrimination items. Neither age nor training condition affected rate of acquisition. Age and training condition affected all other measures (recognition, generalization, and discrimination). Older children and children trained with multiple items generalized more but discriminated less than did other children; these results were obtained even when recognition differences were accounted for. The pattern of results suggests that developmental changes in concept generalization may be due to changes in the liberality of children's response criteria rather than to changes in memory or the ability to abstract information. (Author/MP)

Development of Preschoolers' Learning, Retention, and Generalization of Concepts

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Running Head: Learning, Retention, and Generalization

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Abstract

The present study indicates that both age and variation in training affect children's concept formation, and provides a basis for explaining the effect of age. Sixty-four four and five year olds learned three novel concepts (animal-like, plant-like, and machine-like), each with either four different examples or with one example repeated four times. Following acquisition, children identified a set of recognition, generalization, and discrimination items. Neither age nor training condition affected rate of acquisition, so subsequent results are not attributable to differential exposure. Age and training condition affected all other measures (recognition, generalization, and discrimination). Older children and children trained with multiple items generalized more but discriminated less than did other children; these results obtained even when recognition differences were accounted for. The pattern of results suggests that developmental changes in concept generalization may be due to changes in the liberality of children's response criteria rather than to changes in memory or the ability to abstract information.

Development of Preschoolers' Learning, Retention, and Generalization of Concepts

Children's rapid and largely untutored ability to interact consistently with people and objects is evidence of their skill in organizing and classifying their environments. Rather than treating each encounter with a particular object as a unique, unexpected event, children extend their knowledge from one encounter to another and from one example to another. This nameable, cognitive grouping of distinguishable objects based on common characteristics is a "concept" (Bourne, 1966). Concept formation allows one to gain predictive control over the environment (Nelson, 1974). That a concept has been formed implies that the child has represented experienced instances of that concept in memory. Concepts should be appropriately generalized to previously unexperienced but similar instances but should be discriminated from dissimilar instances.

Daehler, Perlmutter, and Myers (1976) found that children generalized their conceptual knowledge to a degree significantly above chance, but significantly less than the degree of recognition for the examples used in training. Becker, Rosner, and Nelson (1979) found that children appropriately generalized their conceptual knowledge and did so at as high a level as that for recognition of training examples. This finding may simply be due to ceiling level performance. On the other hand, the discrepancy in results could be due to differences in children's ages or the number of training examples used in the two studies. Daehler et al. (1976) trained two and three year olds by

means of repetitions of one example of each concept. Becker et al. (1979) trained four and five year olds with four different examples of each concept.

There is additional evidence that children are more likely to generalize their knowledge to new examples after training with many as opposed to few different examples or only a single example of a concept (e.g., Gagné & Bassler, 1963; Kol'tsova, cited in Razran, 1961; Morrisett & Hovland, 1959; Nelson & Bonvillian, 1978; White & Spiker, 1960). Variation among examples is thought to be necessary for generalization because it establishes a system of associations in memory (Posner, 1973) and allows one better to learn criterial and variable characteristics of concepts (Crafts, 1927).

Age has also been found to be related to concept generalization: older children often appear to generalize their knowledge of concepts to new examples more than younger children do (e.g., Horton & Markman, 1979; Kossan, 1979; Nelson & Nelson, 1978; Saltz & Sigel, 1967). Developmental differences in generalization typically have been explained in terms of either changes in the ability to extract information from examples and form abstract mental representations (e.g., Kendler, 1979; Osler & Kofsky, 1966; Shepp, 1978; Stevenson, 1972; Tighe & Tighe, 1972) or response criteria or tendencies of older children to respond more liberally than younger children (e.g., Saltz & Sigel, 1967). Another viable explanation is that increased generalization results from developmental increases in memory abilities.

It is difficult to distinguish between changes in generalization skills and response bias. Nonetheless, certain patterns of results

would be suggestive of these alternatives. If older children more readily extract information from examples and form abstract mental representations, they might be expected to be disproportionately advantaged by variation in training in comparison to younger children who presumably only memorize individual instances. On the other hand, if older children simply tend to respond more liberally, they would be expected to generalize more (and discriminate less) than younger children. They also might be expected to use the concept names randomly and mislabel items more frequently. Finally, if generalization results from developmental increases in memory abilities, there should be a strong relation between children's memory and their generalization. In the present study training variation was used as a vehicle for assessing these three explanations of age related increases in concept generalization.

Method

Subjects. Sixty-four children from the Minneapolis-St. Paul area participated in the study. Children were drawn from the University of Minnesota preschool, child care center, and art classes as well as from families who volunteered to have their names kept on file for research purposes. There were 16 girls and 16 boys ranging in age from 46 to 54 months (mean age: 50.3 months) and 16 girls and 18 boys ranging in age from 62 to 73 months (mean age: 67.1 months). Children were randomly assigned to single or multiple item training conditions such that there were 16 four year olds and 16 five year olds as well as 15 girls and 17 boys in each condition. An additional 10 four year olds (5 in each training condition) and 4 five year olds (all in the multiple

training condition) were eliminated from the study for failing to learn the names of the concepts within seven trials.

Materials. Stimuli consisted of forty eight 8 mm x 11.5 mm, colored drawings. There were eight different examples of each of six novel concepts, designed on an intuitive basis by the first author. Figure 1 shows examples of the six types of stimuli. The six concepts included two that could be considered animal-like ("daks"), two that could be considered plant-like ("sheens"), and two that could be considered machine-like ("wugs"). The different examples of each type of concept were discriminable and varied in color and detail.

Insert Figure 1 about here.

Nineteen six and seven year olds and 20 adults previously had sorted the 48 pictures twice according to similarity. Wilcoxon signed rank tests indicated that, for both age groups, the six concepts were readily distinguishable from each other. When the pictures were not sorted into these six groups, they tended to be sorted into groups representing the three superordinate categories.

Procedure. Children were tested individually. They were told that they were going to see pictures of three things that they had never seen before and were asked to remember the names of these things when the experimenter said them. Children in the multiple item training condition were then exposed to four examples of one of the types of wug, sheen, and dak. Children in the single item training condition saw only four examples of each concept repeated four times. Conditions were counter-balanced such that half of the children received examples of

one of the wug concepts, one of the sheen concepts, and one of the dak concepts, while the other children received examples of the remaining concept of each category. The 12 training pictures were presented individually in random order. Children saw each picture, heard its name, and were asked to repeat the name. Then the pictures were randomly shuffled and again presented for the children to name. Errors were corrected and children received positive verbal reinforcement for correct answers. In order to reach criterion for acquisition, children had to name all 12 pictures correctly and consecutively. If a child was unable to learn the names by the end of seven trials, s/he was eliminated from the study.

Following acquisition, children were presented with a new set of 27 pictures and were asked to indicate whether each was "a wug, a sheen, a dak, or something different." These pictures consisted of three recognition pictures (i.e., items used in the single item training condition) and 24 generalization items. Twelve generalization items were the untrained examples of the concepts the children had learned; children were expected to extend the concept names to them readily since they were highly similar to the training items. The other 12 items were examples of the wug, sheen, and dak concepts the children had not learned; children were expected to discriminate these items and not extend the concept names to them as readily since, although they were in the same superordinate category, they were quite different from the training items. Thus, the 27 new pictures involved three levels of relative similarity to the training items: identical (training items), similar (same concept), and related (different concepts, same superordinate categories).

Results

The mean proportion correct for each group on each dependent measure is summarized in Table 1.

Insert Table 1 about here.

Acquisition. Children required a mean of 3 trials to reach criterion. A 2 (age) x 2 (training condition) x 2 (sex) analysis of variance revealed no significant main effects or interactions.

Recognition. The mean proportion of correct identification of training items was .82. A 2 (age) x 2 (training condition) x 2 (sex) x 3 (type of item: wug, sheen, dak) mixed analysis of variance indicated that five year olds recognized more training items than did four year olds., $F(1, 56) = 5.88$, $p < .05$. Training condition also was a significant factor, $F(1, 56) = 8.06$, $p < .01$; recognition was greater for children in the single item training condition. No other main effects or interactions were significant.

Generalization to untrained examples of training concepts. Overall, children generalized to 28% of the untrained examples of the concepts. Eighty three percent of the ungeneralized responses were "something different." Since children were asked to choose from among four possible verbal responses, the probability of being correct by chance was .25. Four and five year olds in the single item training condition generalized at a level significantly less than chance, ps < .01; four year olds in the multiple condition generalized at chance level; and five year olds in the multiple item training condition generalized at a level significantly greater than chance, $p < .001$.

A 2 (age) x 2 (training condition) x 2 (sex) x 3 (type of item) mixed analysis of variance indicated that five year olds generalized significantly more than did four year olds, $F(1, 56) = 6.00$, $p < .05$. Likewise, multiple item training resulted in significantly more generalization than did single item training, $F(1, 56) = 41.89$, $p < .001$. No interactions were significant.

Given the nature of the task and the data, this analysis of generalization data was not entirely satisfactory. Although all children required approximately the same number of trials to acquire the concepts (thus having a comparable amount of exposure), not all children were comparably able to recognize the items on which they were trained when these items were embedded in a group of novel items. It was unclear how to interpret the generalization responses of children who did not recognize the training items since this memory is presupposed for concept formation. Lack of recognition on one or two of the recognition items could have represented merely a momentary and insignificant lapse of attention. On the other hand, lack of recognition may have indicated a memory loss or confusion about the task. These possibilities suggest that a clearer interpretation of generalization might be derived from consideration of only the generalization data for concepts on which the child had demonstrated correct recognition of the training item. That is, only generalization performance on concepts for which there was no question about recognition were considered.

In an attempt to deal with these issues an additional analysis was carried out. This analysis involved generalization scores that were

adjusted for recognition performance. If a child failed to recognize the training items for a particular concept, that child's generalization score for that concept was replaced by the mean generalization score for children in the same cell who were able to recognize that training item. These adjusted data again indicated that both younger and older children in the single item training condition generalized at a level significantly less than chance, _p_s $< .001$, while both the four and five year olds in the multiple item training condition generalized at a level significantly greater than chance, _p_s $< .01$. A 2 (age) x 2 (training condition) x 2 (sex) x 3 (type of item) mixed analysis of variance was performed on these adjusted data, with the degrees of freedom for the within-subjects error term decreased for each score adjusted and the degrees of freedom for the between-subjects error term decreased for each of the four children who did not recognize any training items. Again, five year olds generalized more than four year olds, $F(1, 52) = 4.53$, $p < .05$, and multiple item training led to significantly greater generalization than single item training did, $F(1, 52) = 82.93$, $p < .001$.

Generalization to related items. There was little generalization to items only somewhat similar to training items, indicating that children were differentiating these items from the training items and from untrained examples of the training concepts. Both groups of children in the single item training condition and four year olds in the multiple condition generalized to these items at a level significantly less than chance, _p_s $< .05$. Five year olds in the multiple item training condition generalized at chance level.

A 2 (age) x 2 (training condition) x 2 (sex) x 3 (type of item) mixed analysis of variance showed no significant main effect of age. On the other hand, children in the multiple item training condition

generalized to related items more than did children in the single item training condition, $\underline{F}(1, 56) = 17.75$, $\underline{p} < .001$. Two interactions were also significant: age x item x sex, $\underline{F}(2, 112) = 4.89$, $\underline{p} < .01$, and age x item x training condition x sex, $\underline{F}(2, 112) = 3.70$, $\underline{p} < .05$. These interactions were not readily interpretable and therefore will not be discussed further.

The data on children's generalization to categorically related items are open to the same problems as the other generalization data. Thus, these data were treated similarly and an additional analysis was performed. Discrimination in terms of the scores adjusted for recognition performance was not appreciably different from unadjusted performance; children generalized very little to these items. Both four and five year olds in the single item training condition and four year olds in the multiple condition generalized at a level significantly less than chance, $\underline{ps} < .001$. Five year olds in the multiple condition generalized at chance level. Although all children discriminated to a high degree, the analysis of adjusted scores indicated that five year olds generalized more than four year olds, $\underline{F}(1, 52) = 4.80$, $\underline{p} < .05$. Also, children trained with multiple examples generalized to the related items more than did children in the single item training condition, $\underline{F}(1, 52) = 27.68$, $\underline{p} < .001$. There were again significant interactions of age x item x sex, $\underline{F}(2, 78) = 6.15$, $\underline{p} < .01$, and of age x item x training condition x sex, $\underline{F}(2, 78) = 5.72$, $\underline{p} < .01$, that were not readily interpretable.

<u>Mislabeling of items with incorrect concept names</u>. When children did not generalize, they were far more likely to label the generalization

items "something different" than to mislabel them with one of the other concept names. A 2 (age) x 2 (training condition) x 2 (sex) analysis of variance was performed on mislabelings of the recognition and generalization items. Training condition had a significant effect on mislabeling: children trained with multiple items mislabeled items more frequently than did children trained with single items, $\underline{F}(1, 56) = 7.49$, $\underline{p} < .01$. No other main effects or interactions were significant.

Discussion

The results of this study indicate that four and five year olds trained with either single or multiple examples of novel concepts learned the concepts at comparable rates. However, both age and variation in training affected recognition and generalization performance. All children's recognition was good, although it was better by five year olds than by four year olds and by children trained with single items than by children trained with multiple items. None of the children generalized at high levels, but there was greater generalization by five year olds than four year olds and by children trained with multiple examples than those trained with single examples. This pattern of generalization was observed with untrained examples of the concepts on which children were trained as well as with items only related to training items.

The lack of age or condition differences in acquisition made interpretation of the recognition and generalization data easier. Nevertheless, this finding seems a bit anomalous, and probably can be accounted for by the differential subject loss from each age group and condition. That is, a high proportion of the children eliminated from

the study for failure to reach criterion were four year olds and all of the five year olds who were eliminated were in the multiple item training condition. It is likely that this differential attrition reflects developmental and condition effects on learning. Moreover, it suggests that the present findings are conservative estimates of the effects of these factors.

The high level of recognition performance and age difference in recognition are predictable in light of previous evidence of good recognition and age-related improvement in recognition during the preschool years (e.g., Perlmutter & Myers, 1974; 1976). Likewise, the condition effect on recognition is not surprising given that multiple training entailed a considerably greater memory load and that children with single item training saw each recognition item four times as often as children with multiple item training did.

The recognition differences are interesting in themselves, but make it difficult to interpret the generalization data. However, the results of an analysis that accounted for recognition effects converged to a remarkable degree, and suggested effects of training condition and age.

Since the formation of a generalizable concept entails learning criterial and variable characteristics, children in the single item training condition were at a disadvantage. They learned to discriminate a single example of each concept from single examples of the other concepts, but had no opportunity to learn which invariant characteristics defined the concepts nor which characteristics were variable. Thus, they essentially learned only proper names for three distinctive items.

Children in the multiple item training condition, on the other hand, were able to learn which characteristics the four examples of each concept had in common and which irrelevant ones varied. Thus, they had the opportunity to learn more general concepts or category names that they could appropriately extend to new examples. The signifi·· effect of condition on generalization is therefore not surprising and supports the theoretical work of Posner (1973) and Crafts (1927).

The age-related increase in generalization cannot be interpreted conclusively. However, the pattern of results suggests that it was not due to a developmental increase in memory performance. The age effect still obtained when recognition performance was accounted for in an additional analysis on adjusted data. Several factors also suggest that age-related improvements in the ability to abstract information did not contribute importantly to the observed age difference in generalization. Five year olds did not benefit significantly more than four year olds from variation in training. Nevertheless, there may have been some developmental improvement in the ability to abstract information; five year olds trained with multiple items generalized more, relative to chance, than the other children. On the other hand, a liberality, or response criterion, explanation of age differences in generalization was supported. Five year olds generalized more than four year olds to untrained examples of training concepts as well as to dissimilar but related items. This suggests that five year olds tended to be more liberal in applying their conceptual knowledge. However, the fact that both groups generalized more to untrained examples of training concepts than to dissimilar but related items and

only rarely used concept names inappropriately suggests that a response set cannot entirely explain the generalization that was observed.

In summary, these results extend our understanding of developmental changes in learning, retention, and generalization of concepts, demonstrating these changes even within a narrow age range (four to five years). In a task in which all children were trained to an acquisition criterion on three novel concepts, neither age nor variation in training had significant effects on rate of acquisition, although differential attrition suggested that these factors did affect learning. Both age and variation in training affected recognition of training items, generalization to similar items, and discrimination from dissimilar but related items. The pattern of results suggests that changes in the liberality of children's response criteria contribute to developmental changes in concept generalization, as may changes in the ability to abstract information from examples, but that improvement in memory is not a contributing factor.

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Footnote

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Table 1

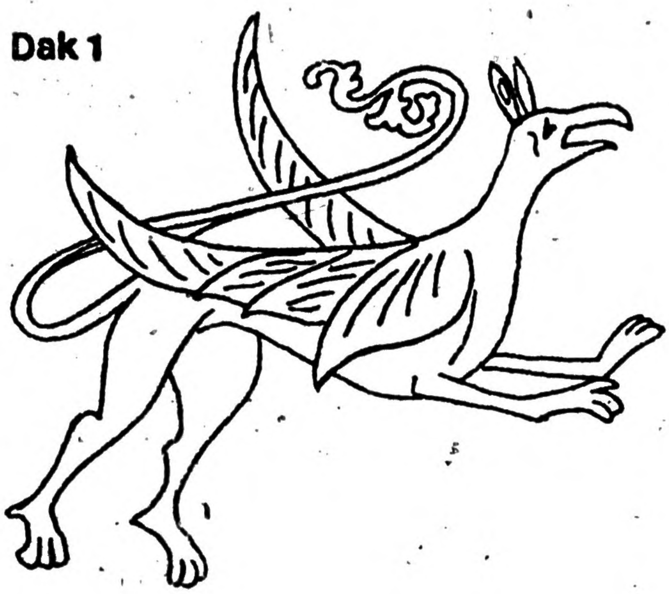
Summary of Results for Each Training Condition and Age Group

	Trials to Acquisition	Proportion of Identifications			Mislabeling
		Recognition Items	Generalization Items	Discrimination Items	
Four Year Olds					
Single item training	3.19	.896	.047	.021	.056
Multiple item training	3.50	.583	.354	.151	.190
Summed over condition	3.35	.740	.201	.086	.123
Five Year Olds					
Single item training	2.19	.937	.094	.031	.032
Multiple item training	3.13	.875	.630	.240	.130
Summed over condition	2.66	.906	.362	.136	.081

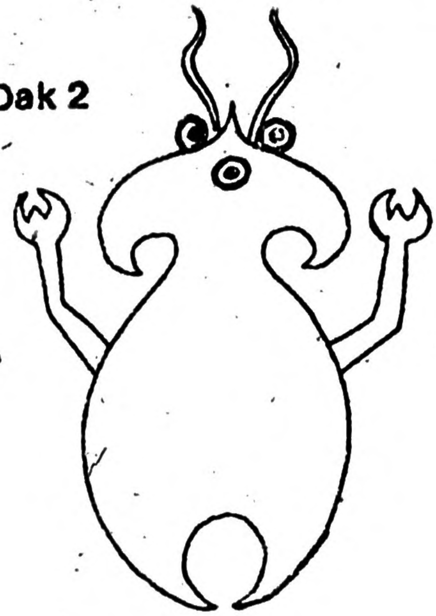
Figure Caption

Figure 1. Examples of each of the six concepts used in training.

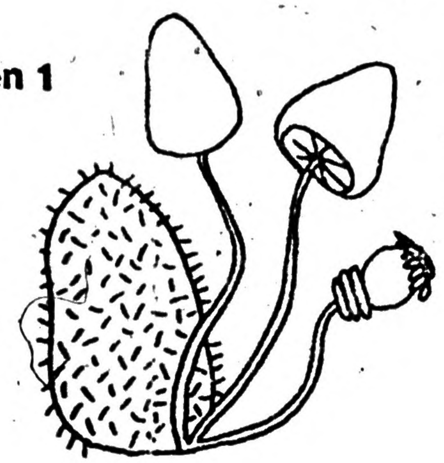
Dak 1



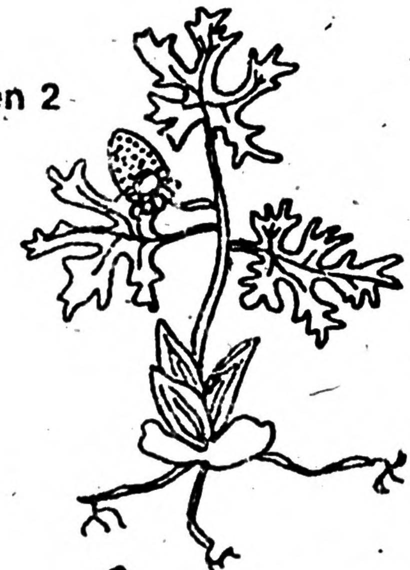
Dak 2



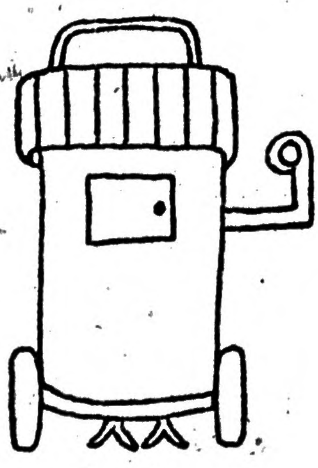
Sheen 1



Sheen 2



Wug 1



Wug 2